STRUCTURE AND TRANSFORMATION OF MATTER

A basic understanding of matter is essential to the conceptual development of other big ideas in science. In the elementary years of conceptual development, students will be studying properties of matter and physical changes of matter at the macro level through direct observations, forming the foundation for subsequent learning. During the middle years, physical and chemical changes in matter are observed, and students begin to relate these changes to the smaller constituents of matter—namely, atoms and molecules. By high school, students will be dealing with evidence from both direct and indirect observations (microscopic level and smaller) to consider theories related to change and conservation of matter. The use of models (and an understanding of their scales and limitations) is an effective means of learning about the structure of matter. Looking for patterns in properties is also critical to comparing and explaining differences in matter.

6th Grade	7th Grade	8th Grade
Physical Science		
SC-M6 1.1.1 Students will explain how or why mixtures can be separated using physical properties. A mixture of substances often can be separated into the original substances by using one or more of it's characteristic physical properties. Strategies for separating mixtures should be explored and explained. DOK 2	**SC-M7-1.1.1 Students will:** • **classify substances according to their chemical/reactive properties;** • **infer real life applications for substances based on chemical/reactive properties.** Simple experiments should be performed in order to provide data to support the conclusion that the chemical properties of a substance cause it to react in predictable ways with other substances to form compounds with different characteristic properties. In chemical reactions, the total mass is conserved. Substances are often classified into groups if they react in similar ways. The patterns which allow classification can be used to infer or understand real life applications for those substances. DOK 3	**SC-H8-1.1.1 Students will:** • **interpret models/representations of elements;** • **classify elements based upon patterns in their physical (e.g., density, boiling point, solubility) and chemical (e.g., flammability, reactivity) properties.** Models enhance understanding that an element is composed of a single type of atom. Organization/interpretation of data illustrates that when elements are listed according to the number of protons, repeating patterns of physical (e.g., density, boiling point, solubility) and chemical properties (e.g., flammability, reactivity), can be used to identify families of elements with similar properties. DOK 2
SC-M6-1.1.2 Students will identify and describe evidence of chemical changes in matter. Simple experiments should be performed in order to provide data to support the conclusion that the chemical properties of a substance cause it to react in predictable ways with other substances to form compounds with different characteristic properties. In chemical reactions, the total mass is conserved. Substances are often classified into groups if they	**SC-M7-1.1.2 Students will:** • **classify elements and compounds according to their properties;** • **compare properties of different combinations of elements.** Observations of simple experiments illustrate that chemical elements do not break down during normal laboratory reactions such as heating, exposure to electric currents, or reaction with acids. Elements	*SC-H8-1.1.2 Students will understand that matter is made of minute particles called atoms, and atoms are composed of even smaller components. The components of an atom have measurable properties such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and the electrons holds the atom together.*

react in similar ways. The patterns that allow classification can be used to infer or understand real life applications for those substances. DOK 2	combine in many ways to produce compounds. Common patterns emerge when comparing and contrasting the properties of compounds to the elements from which they are made. Understanding of these patterns allows for evidence- based predictions of new or different combinations of elements/compounds. DOK 2	
		SC-H8-1.1.3 Students will understand that the atom's nucleus is composed of protons and neutrons that are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called different isotopes of the element.
		SC-H8-1.1.4 Students will describe interactions which cause the movement of each element among the solid Earth, oceans, atmosphere, and organisms (geochemical cycles). Earth is a system containing essentially a fixed amount of each stable chemical atom or element that can exist in several different reservoirs. The interactions within the earth system cause the movement of each element among reservoirs in the solid Earth, oceans, atmosphere, and organisms as part of geochemical cycles. Information should be gathered and representations created to illustrate the movement of elements in the earth system. DOK 2

Motion and Forces

Whether observing airplanes, baseballs, planets, or people, the motion of all bodies is governed by the same basic rules. In the elementary years of conceptual development, students need multiple opportunities to experience, observe, and describe (in words and pictures) motion, including factors (i.e., pushing and pulling) that affect motion. At the middle level, qualitative descriptions of the relationship between forces and motion will provide the foundation for quantitative applications of Newton's Laws. These ideas are more fully developed at the high school level along with the use of models to support evidence of motion in abstract or invisible phenomena such as electromagnetism**.**

6th Grade	7th Grade	8th Grade
Physical Science		
SC-M6-1.2.1 Students will describe friction and make inferences about it's effects on the motion of an object. When an unbalanced force (i.e., friction) acts on an object, the change in speed or direction depends on the size and direction of the force. DOK 3	**SC-M7-1.2.1 Students will explain the cause and effect relationship between straight-line motion and unbalanced forces.** An object remains at rest or maintains a constant speed and direction of motion unless an unbalanced force acts on it (i.e., inertia). When an unbalanced force acts on an object, the change in speed or direction depends on the size and direction of the force. DOK 3	**SC-M8-1.2.1 Students will describe and explain the effects of balanced and unbalanced forces on motion as found in real-life phenomena.** Objects change their motion only when a net force is applied. Newton's Laws of Motion are used to describe the effects of forces on the motion of objects. DOK 3

THE EARTH AND THE UNIVERSE

The Earth system is in a constant state of change. These changes affect life on earth in many ways. Development of conceptual understandings about processes that shape the Earth begin at the elementary level with understanding *what* Earth materials are and that change occurs. At the middle level, students investigate *how* these changes occur. Finally, at the high school level, most of the emphasis is on *why* these changes occur. An understanding of systems and their interacting components will enable students to evaluate supporting theories of earth changes.

At the heart of elementary students' initial understanding of the Earth's place in the universe is direct observation of the earth-sun-moon system. Students can derive important conceptual understandings about the system as they describe interactions resulting in shadows, moon phases, and day and night. The use of models and observance of patterns to explain common phenomena is essential to building a conceptual foundation and supporting ideas with evidence at all levels. In middle school, students begin to look beyond what can be directly observed as they explore the earth-sun-moon system, as well as the rest of our solar system, employing the concept of scale within their models. Patterns play an important role as students seek to develop a conceptual understanding of gravity in their world and in the universe. High school is the time to bring all of the ideas together to look at the universe as a whole. Students will use evidence to evaluate and analyze theories related to the origin of the universe and all components of the universe.

6th Grade	7th Grade	8th Grade
Earth/Space Science		
SC-M6-2.3.1 Students will explain and predict phenomena (e.g., day, year, moon phases, eclipses) based on models/representations or data related to the motion of objects in the solar system (e.g., earth, sun, moon). Observations and investigations of patterns indicate that most objects in the solar system are in regular and predictable motion. Evaluation of this data explains such phenomena as the day, the year, phases of the moon, and eclipses. DOK 3	**SC-M7-2.3.1 Students will make inferences and predictions related to changes in the Earth's surface or atmosphere based on data/evidence.** The Earth's processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are predictable and similar to those that occurred in the past. Analysis of evidence from Earth's history substantiates the conclusion that the planet has also been influenced by occasional catastrophes such as the impact of an asteroid or comet. DOK 3	**SC-H8-2.3.1 Students will describe various techniques for estimating geological time (i.e., radioactive dating, observing rock sequences, comparing fossils);** Techniques used to estimate geological time include using radioactive dating, observing rock sequences, and comparing fossils to correlate the rock sequences at various locations. Deductions can be made based on available data and observation of models as to the age of rocks/fossils. DOK 2

SC-M6-2.3.2 Students will explain cause and effect relationships in the Rock cycle. Materials found in the lithosphere and mantle are changed in a continuous process called the rock cycle, which can be investigated using a variety of models. Cause and effect relationships should be explored in order to draw conclusions and make evidence-based predictions of the continually changing materials. DOK 2	**SC-M7-2.3.2 Students will explain the layers of the Earth and their interactions.** The use of models/diagrams/graphs helps illustrate that the Earth is layered. The lithosphere is the thin crust and the upper part of the mantle. Lithospheric plates move slowly in response to movements in the mantle. There is a dense core at the center of the Earth. DOK 2	*SC-H8-2.3.2 Students will understand that earthquakes and volcanic eruptions can be observed on a human time scale, but many processes, such as mountain building and plate movements, take place over hundreds of millions of years.*
SC-M6-2.3.3 Students will compare constructive and destructive forces on Earth in order to make predictions about the nature of landforms. Landforms are a result of a combination of constructive and destructive forces. Collection and analysis of data indicates that constructive forces include crustal deformation, faulting, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion. DOK 2	**SC-M7-2.3.3 Students will describe the concept of gravity and the effect of gravitational force from the sun on the moon and Earth.** Simple investigations or models will help conceptualize the fact that gravity is the force that keeps the planets in orbit around the Sun and governs the rest of the motion in the solar system. The gravitational pull of the Sun and moon on Earth's oceans as the major cause of tides can be understood from generalizations based on evidence. DOK 2	**SC-H8-2.3.3 Students will** • **explain the transfer of Earth's internal heat in the mantle (crustal movement, hotspots, geysers);** • **describe the interacting components (convection currents) within the Earth's system.** Investigations using models should demonstrate that the outward transfer of Earth's internal heat drives convection circulation in the mantle. This causes the crustal plates to move on the face of the Earth. Observations of the interacting components within the system promote conceptualization of real life phenomena. DOK 2
		SC-H8-2.3.4 Students will understand that the Sun, Earth, and the rest of the solar system formed approximately 4.6 billion years ago.

Unity and Diversity

All matter is comprised of the same basic elements, goes through the same kinds of energy transformations, and uses the same kinds of forces to move. Living organisms are no exception. Elementary students begin to observe the macroscopic features of organisms in order to make comparisons and classifications based upon likenesses and differences. Looking for patterns in the appearance and behavior of an organism leads to the notion that offspring are much like the parents, but not exactly alike. In middle school, students begin to compare, contrast, and classify the microscopic features of organisms—the cells, as well as investigate reproduction as the essential process to the continuation of all species. Expected patterns of genetic traits are predicted. Distinctions are made between learned behaviors and inherited traits. At the high school level, an in-depth study of the specialization and chemical changes occurring at the cellular level builds upon the foundational ideas developed earlier to investigate DNA and effects of alterations in DNA for an individual organism as well as for a species. Emphasis at every level should be placed upon the understanding that while every living thing is composed of similar small constituents that combine in predictable ways, it is the subtle variations within these small building blocks that account for both the likenesses and differences in form and function that create the diversity of life.

6th Grade	7th Grade	8th Grade
Biological Science		
SC-M6-3.4.1 Students will describe the relationship between cells, tissues, and organs in order to explain their function in multicellular organisms. Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form tissues. Different tissues are, in turn, grouped together to form larger functional units called organs. Examination of cells, tissues, and organs reveals that each type has a distinct structure and set of functions that serve the organism. DOK 3	**SC-M7-3.4.1 Students will** • **describe the role of genes/chromosomes in the passing of information from one generation to another (heredity);** • **compare inherited and learned traits.** Every organism requires a set of instructions for specifying its traits. This information is contained in genes located in the chromosomes of each cell that can be illustrated through the use of models. Heredity is the passage of these instructions from one generation to another and should be distinguished from learned traits. DOK 2	**SC-H8-3.4.1 Students will explain the relationship between structure and function of the cell components using a variety of representations.** Observations of cells and analysis of cell representations point out that cells have particular structures that underlie their function. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules that form a variety of specialized structures. These structures carry out specific cell functions. DOK 3
	SC-M7-3.4.2 Students will describe and compare sexual and asexual reproduction. Reproduction is a characteristic of all living systems and is essential to the continuation of every species as evidenced through observable patterns. A distinction should be made between organisms that reproduce asexually, and those that reproduce sexually. In species that reproduce sexually, including humans and	*SC-H8-3.4.2 Students will understand that in the development of multicellular organisms, cells multiply (mitosis) and differentiate to form many specialized cells, tissues, and organs. This differentiation is regulated through the expression of different genes.*

	plants, male and female sex cells carrying genetic information unite to begin the development of a new individual. DOK 2	
SC-M6-3.4.2 Students will make inferences about the factors influencing behavior based on data/evidence of various organism's behaviors. Behavior is one kind of response an organism may make to an internal or environmental stimulus. Observations of organisms, data collection/analysis, support generalizations/conclusions that a behavioral response is a set of actions determined in part by heredity and in part from experience. A behavioral response requires coordination and communication at many levels including cells, organ systems, and organisms. DOK 2		**SC-H8-3.4.3 Students will form or justify conclusions as to whether a response is innate or learned using data/evidence on behavioral responses to internal and external stimuli.** Behavioral responses to internal changes and external stimuli can be innate or learned. Analysis/interpretation of data from investigations and research should confirm that responses to external stimuli can result from interactions with the organism's own species or other species, as well as environmental changes. DOK 3
		SC-H8-3.4.4 Students will describe and explain patterns found within groups of organisms in order to make biological classifications of those organisms. Observations and patterns found within groups of organisms allow for biological classifications based on how organisms are related. DOK 2
		SC-H8-3.4.5 Students will understand that multicellular animals have nervous systems that generate behavior. Nerve cells communicate with each other by secreting specific molecules.

BIOLOGICAL CHANGE

The only thing certain is that everything changes. Elementary students build a foundational knowledge of change by observing slow and fast changes caused by nature in their own environment, noting changes that humans and other organisms cause in their environment, and observing fossils found in or near their environment. At the middle school level, students study relationships among populations and ecosystems that contribute to the success or demise of a specific population or species. Students construct basic explanations that can account for the great diversity among organisms. The stage is set for high school students to evaluate the role natural selection plays in the diversity of species. Modern ideas of evolution provide a scientific explanation for three main sets of observable facts about life on earth: the enormous number of different life forms we see about us, the systematic similarities in anatomy and molecular chemistry we see within that diversity, and the sequence of changes in fossils found in successive layers of rock that have been formed over more than a billion years (*Science for All Americans, p. 67)*.

6th Grade	7th Grade	8th Grade
Biological Science		
SC-M6-3.5.1 Students will explain that biological change over time accounts for the diversity of species developed through gradual processes over many generations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment. DOK 2	**SC-M7-3.5.1 Students will** • **describe the usefulness of fossil information to make conclusions about past life forms and environmental conditions;** • **explain the cause and effect relationship of the extinction of a species and environmental changes.** Extinction of species is common and occurs when the adaptive characteristics of a species are insufficient to allow its survival. Most of the species that have lived on Earth no longer exist. Fossils provide evidence of how environmental conditions and life have changed. DOK 3	**SC-H8-3.5.1 Students will draw conclusions and make inferences about the consequences of change over time that can account for the similarities among diverse species.** The consequences of change over time provide a scientific explanation for the fossil record of ancient life forms and for the striking molecular similarities observed among the diverse species of living organisms. DOK 3
SC-M6-3.5.2 Students will understand that regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive. Maintaining a stable internal environment is essential for an organism's survival.		

Energy transformations are inherent in almost every system in the universe—from tangible examples at the elementary level, such as heat production in simple earth and physical systems to more abstract ideas beginning at middle school, such as those transformations involved in the growth, dying and decay of living systems. The use of models to illustrate the often invisible and abstract notions of energy transfer will aid in conceptualization, especially as students move from the macroscopic level of observation and evidence (primarily elementary school) to the microscopic interactions at the atomic level (middle and high school levels). Students in high school expand their understanding of constancy through the study of a variety of phenomena. Conceptual understanding and application of the laws of thermodynamics connect ideas about matter with energy transformations within all living, physical, and earth systems.

6th Grade	7th Grade	8th Grade
Unifying Ideas		
SC-M6-4.6.1 Students will describe or explain the cause and effect relationships between oceans and climate. Oceans have a major effect on climate, because water in the oceans holds a large amount of heat. DOK 2	*SC-M7-4.6.1 Students will understand that Earth systems have sources of energy that are internal and external to the [illegible]. The Sun is the major external source of energy.*	**SC-H8-4.6.1 Students will** • **explain the cause and effect relationships between global climate and energy transfer;** • **use evidence to make inferences or predictions about global climate issues.** Global climate is determined by energy transfer from the Sun at and near Earth's surface. DOK 3
SC-M6-4.6.2 Students will describe • **the effect of the Suns' energy on the earth system;** • **the connection/relationship between the Sun's energy and seasons.** The Sun is the major source of energy for Earth. The water cycle, winds, ocean currents, and growth of plants are affected by the Sun's energy. Seasons result from variations in the amount of the Sun's energy hitting Earth's surface. DOK 3	**SC-M7-4.6.2 Students will** • **describe where energy comes from (and goes next) in examples that involve several different forms of energy: heat, light, motion of objects, and chemical.** • **Explain, qualitatively or quantitatively, that heat lost by hot object equals the heat gained by cold object.** Heat energy is the disorderly motion of molecules. Heat can be transferred through materials by the collisions of atoms or across space by radiation. If the material is fluid,	**SC-H8-4.6.2 Students will** • **describe or explain energy transfer and energy conservation;** • **evaluate alternative solutions to energy problems.** Energy can be transferred in many ways, but it can neither be created nor destroyed. DOK 3

	currents will be set up in it that aid the transfer of heat. To change something's speed, to bend or stretch things, to heat or cool them, to push things together or tear them apart all require transfers (and some transformations) of energy. Heat lost by hot object equals the heat gained by cold object. This is an energy conversation statement. Whenever hot and cold objects are put in contact, heat energy always transfers from the hot object to the cold object and this continues until all the mass is at the same temperature. Students should understand that heat produced by burning comes from the release of chemical energy of the substance. DOK 3	
SC-M6-4.6.3 Students will understand that, on its own, heat travels only from higher temperature object/region to lower temperature object or region. Heat will continue to flow in this manner until the objects reach the same temperature. For example, a cup of hot water will continue to cool down until it comes to the same temperature as the surrounding area. Usually when heat is transferred to or from an object, the temperature changes. The temperature increases if heat is added and the temperature decreases if the heat is removed.		*SC-H8-4.6.3 Students will understand that all energy can be considered to be kinetic energy, potential energy, or energy contained by a field (e.g., electric, magnetic, gravitational).*
	SC-M7-4.6.3 Students will understand that waves are one way that energy is transferred. Types of waves include sound, light, earthquake, ocean, and electromagnetic.	**SC-H8-4.6.4 Students will** • **analyze information/data about waves and energy transfer;** • **describe the transfer of energy via waves in real life phenomena.** Waves, including sound and seismic waves, waves on water, and electromagnetic waves, can transfer energy when they interact with matter. DOK 2
	SC-M7-4.6.4 Students will describe or represent the flow of energy in ecosystems, using data to draw conclusions about the role of organisms in an ecosystem.	**SC-H8-4.6.5 Students will** • **describe the relationships between organisms and energy flow in ecosystems (food chains and energy pyramids);** • **explain the effects of change to any component of the ecosystem**

	For most ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism in food webs. DOK 3	**component of the ecosystem.** Energy flows through ecosystems in one direction from photosynthetic organisms to herbivores to carnivores and decomposers. DOK 2

INTERDEPENDENCE

It is not difficult for students to grasp the general notion that species depend on one another and on the environment for survival. But their awareness must be supported by knowledge of the kinds of relationships that exist among organisms, the kinds of physical conditions that organisms must cope with, the kinds of environments created by the interaction of organisms with one another and their physical surroundings, and the complexity of such systems. Elementary learners need to become acquainted with ecosystems that are easily observable to them by beginning to study the habitats of many types of local organisms. Students begin to investigate the survival needs of different organisms and how the environment affects optimum conditions for survival. In middle school, students should be guided from specific examples of the interdependency of organisms to a more systematic view of the interactions that take place among organisms and their surroundings. At the high school level, the concept of an ecosystem should bring coherence to the complex array of relationships among organisms and environments that students have encountered. Students growing understanding of systems in general will reinforce the concept of ecosystems. Stability and change in ecosystems can be considered in terms of variables such as population size, number and kinds of species, productivity, and the effect of human intervention. (*adapted from Benchmarks for Science Literacy)*

6th Grade	7th Grade	8th Grade
Unifying Ideas		
SC-M6-4.7.1 Students will describe the consequences of change in one or more abiotic factors on a population within an ecosystem. The number of organisms an ecosystem can support depends on the resources available and abiotic factors (e.g., quantity of light and water, range of temperatures, soil composition). DOK 2	**SC-M7-4.7.1 Students will compare abiotic and biotic factors in an ecosystem in order to explain consequences of change in one or more factors.** The number of organisms an ecosystem can support depends on the resources available and abiotic factors (e.g., quantity of light and water, range of temperatures, soil composition). Given adequate biotic and abiotic resources and no diseases or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem. DOK 3	**SC-H8-4.7.1 Students will describe the interrelationships and interdependencies within an ecosystem and predict the effects of change on one or more components within an ecosystem.** Organisms both cooperate and compete in ecosystems. Often changes in one component of an ecosystem will have effects on the entire system that are difficult to predict. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years. DOK 3
		SC-H8-4.7.2 Students will • **explain the interactions of the components of the Earth system (e.g., solid Earth, oceans, atmosphere, living organisms);** • **propose solutions to detrimental interactions.**

		Interactions among the solid Earth, the oceans, the atmosphere, and living things have resulted in the ongoing development of a changing Earth system. DOK 3